the time being. At times, Lassar's paste seems to work well, while the boric acid ointment (U. S. P.) or the white percipitate ointment, 5 per cent., may be used. As a prophylactic to those predisposed simple protective applications of petrolatum and paraffine are indicated on the approach of cold weather. In all cases the patient should be cautioned to keep the hands out of water as much as possible, and to avoid all local irritants. The ideal treatment to be advised is a change of climate to a warmer region, a treatment always followed with a disappearance of the trouble.

In conclusion we wish to thank Dr. O. T. Schultz, of the Pathological Department of the Western Reserve University, for his valuable assistance and suggestions in the histological study of this paper. To him also thanks are due for the taking of the photomicrographs.

EXPERIMENTAL STUDY OF THE EFFECTS OF URETERAL OBSTRUCTION ON KIDNEY FUNCTION AND STRUCTURE.[1]

By Edwin Beer, M.D.,

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The following work was begun over four years ago, to determine, if possible, how long a ureter might be tied off, before making an ureterovesical anastomosis, without sacrificing the involved kidney's functional integrity. In the course of difficult pelvic dissections it is well known that the ureters are occasionally injured and at times the attempt to repair the damage protracts the original operation to a dangerous degree. To avoid this prolongation, numerous operators have resorted to direct ligation of the involved ureter[2] above the point of injury, relying upon the natural process of atrophy to take care of the thus excluded kidney. If an operator is thus forced to exclude the kidney of one side, either actuated by such doubts as are engendered by undue prolongation of the operation, or by reason of the fact that the operative technique appears to be too difficult, the possibility of a later operation anastomosing the excluded side with the bladder has been completely ignored, so far as I have been able to discover in a study of the literature. To determine how long such a kidney could wait without losing its functional adequacy was the original impulse for this study, in the course of which many other interesting points developed. In this paper I expect, therefore, as briefly as possible, to bring all these facts together without extensive narration of numerous experimental details involved.

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[1] Read before the Surgical Section of the New York Academy of Medicine, 1912.

[2] L. Landau, Deut. med. Woch., 1900; Wassiljew, Deut. Zeit. f. Chirurgie, 1907, lxxxix; A. V. Rosthorn, Jour. Amer. Med. Assoc., 1906, p. 1881.

All the work was done on some 60 dogs in the surgical research laboratory of Columbia University. To the gentlemen in charge of this laboratory, as well as the students who assisted me, I owe a debt of gratitude, which I gladly take this opportunity to express.

I. Hydronephrosis May Result from Infection of the Ureteropelvic Tract Without Stenosis. A series of experiments was made with the object of determining the effect of direct injection of cultures into the ureter after extraperitoneal exposure of the same without in any way injuring its lumen by artificial stenosis. Colon bacilli were injected through a fine needle. The involved kidney and ureter were removed at varying times, and regularly showed well-marked hydronephrosis and hydroureter. In the earliest case the kidney was examined nine days after the injection, and the organ was enlarged and the pelvis moderately dilated. In another case, after fourteen days, the kidney was removed and it was practically normal, except for well-marked hydronephrosis. In another case, after twenty-one days, a good-sized hydronephrotic sac was present.

In none of the cases were abscesses produced in the kidney parenchyma.

II. Hydroureter and Hydronephrosis of an Extreme Degree, in Time Leading to Complete Parenchymatous Atrophy, Follow Injection of Infectious Organisms Above a Stenosis. If the same technique is followed as was used in Group I plus complete or incomplete ligation of the ureter, whether with *catgut* or with *silk*, an extreme degree of distention of the pelvis and ureter follow, unless the injected bacteria are too virulent, when pyonephrosis or pyelonephritis and early death follow. The early pictures are very much as in group I. Thus already in five days a moderate hydronephrosis has developed. In another case in eleven days there was a marked dilatation with some perinephritis. In another in twelve days, the same picture. In cases lasting thirty-five days a very large hydronephritic sac developed despite the use of a catgut ligature in producing the stenosis. In still another case, after fifty-six days, nothing but a large sac was left representing the destroyed organ.

III. After Developing a Primary Hydroureter and Hydronephrosis of a Mild Degree, the Kidney Undergoes Atrophy if the Ureter is Tied and no Infection is Superadded. If the same technique is used as in group II, and no organisms are introduced into the ureter, there is a primary dilatation above the stenosis, which gradually recedes after the first two or three weeks, and then the pelvis becomes folded on itself and the kidney parenchyma gradually atrophies. This atrophy becomes so complete that at the end of five months (Case 9) the excluded kidney is nothing more than a firm fibrous mass, measuring from pole to pole one inch and from sinus to convexity one-half inch, with folded enlarged pelvis and ureter. These phenomena are of importance in connection with the problem which led to this series of experiments, as they bear upon the essential question that is involved, that is, the functional adequacy of an excluded kidney.

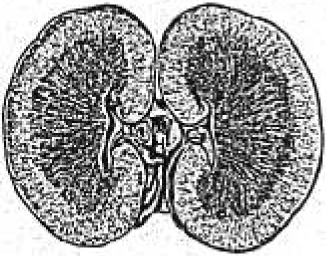


FIG. 1.—Normal kidney with slit-like pelvis.

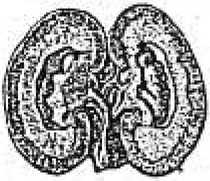


FIG. 2.—Atrophic kidney, three months after ligation; no infection.

From this series of observations it seemed likely that the excluded organ was able to secrete up to about the third week as evidenced by the dilatation and distention of pelvis and ureter up to this date. It also appeared that after these three weeks the function was materially impaired as the distention, probably an evidence of secretory activity, disappeared. Chemical examination of the fluid in the distended ureter showed varying amounts of urea, which seemed corroborative of this view point. Fluid removed three weeks after ligation showed no urea in one case; in another, twenty-four days after ligation, only 0.005 gram per cubic centimeter, whereas fourteen days after exclusion in another case the urea was as high as 5 per cent.

IV. IF A KIDNEY IS EXCLUDED UP TO THREE TO FOUR WEEKS AND THEN ITS URETER IS REIMPLANTED IN THE BLADDER, THE KIDNEY SEEMS CAPABLE OF CARRYING ON ALL THE EXCRETORY

WORK OF BOTH ORGANS. To adequately test the functional capacity of the reimplanted kidney, it was necessary to remove the other kidney. Cystoscopic examinations with indigo carmine, though repeatedly made, I did not accept as conclusive evidence of renal adequacy or inadequacy. Consequently the most exacting test was resorted to and nephrectomy of the second organ performed. In human surgery we will not be called upon to perform any such test, nor is such a degree of adequacy required. If one can reimplant an excluded kidney that has only 50 per cent. of

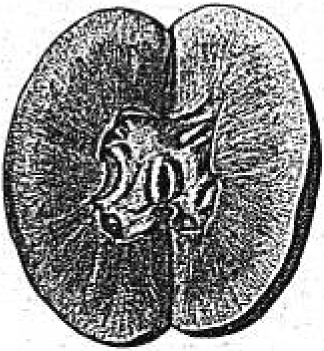


FIG. 3—Two weeks after ligation plus infection (hydronephrosis).

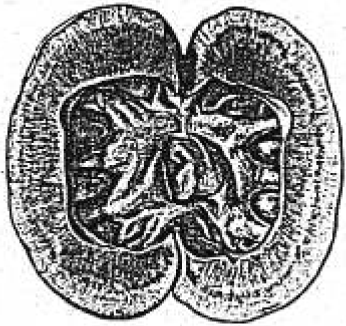


FIG. 4.—Four weeks after ligation of ureter plus infection (hydronephrosis).

the total renal capacity it is that much gain, as all cases coming into this category must have a second adequate organ.

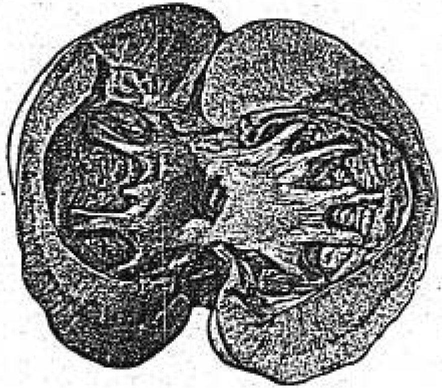
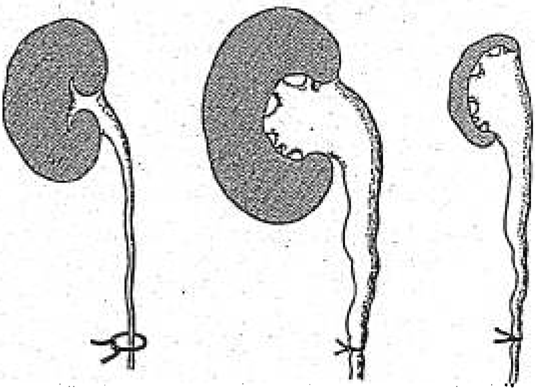


Fig. 5.—No. 226. Exclusion of three weeks. After nephrectomy of the other organ animal lived on this kidney until the ureter became plugged with a calculus, almost two months after removal of second kidney.



Normal kidney.

Three weeks after ligation.

Three months after ligation.

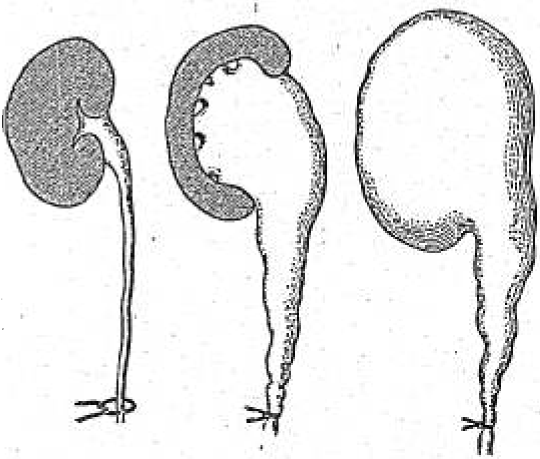
Fig. 6.—Aseptic series.

To demonstrate the evidence upon which the conclusions just mentioned are based, I shall report several experiments in detail. The accompanying drawings, Figs. 1 to 7, from specimens, together with the diagrams, illustrate well the processes just described.

Experiment. (215) Male dog.

March 24, 1909. First operation. Through low laporatomy the right ureter was exposed at insertion into bladder. Silk ligature tied at this point.

March 31, 1909. A low left-sided Kammerer incision. Bladder drawn into wound after separating omental adhesions. The ureter was found dilated moderately with clear amber-colored fluid. An anastomosis of ureter and bladder was made, side to side, by means of a silk ligature (McGraw technique), reinforced with Lembert sutures.



Normal kidney. Three weeks after ligation. Three months after ligation.

FIG. 7.—Septic series.

April 24, 1909. Dog in fine condition

May 29, 1909. Left lumbar nephrectomy.

September 1, 1909. Dog died.

Autopsy. Bladder contains amber-colored fluid; specific gravity 1024; urea 0.2 per cent.; alkaline; microscopically, many pus cells and inorganic salts. The pelvis of the kidney and ureter contain mucopus full of gravel. The parenchyma shows numerous abscesses.

The pelvis is dilated. The new opening in the bladder is surrounded by edematous tissue, which has stenosed it, preventing ready emptying of distended ureter into bladder.

Remarks. In this dog the right kidney was excluded for one week and then the corresponding ureter was implanted in the bladder. After the dog had thoroughly recovered from these operations the adequacy of this kidney was tested by removing the left kidney. The dog continued to live for over three months, showing no signs of renal insufficiency. Had not infection supervened death might not have resulted when it did. In brief, this dog's right kidney, though it had been excluded from work for seven days, was capable of carrying on all the renal excretory work of the organism.

Experiment. (226). Male dog.

April 3, 1909. First operation. Right ureter exposed close to bladder by transperitoneal route, and ligated.

April 17, 1909. In excellent condition.

April 24, 1909. Three weeks after ligation of ureter the anastomosis between the dilated ureter and bladder was made by a double row of sutures. Cultures[3] from dilated ureter, which contained bloody turbid fluid, showed Staphylococcus albus.

May 8, 1909. Doing well.

May 22, 1909. Nephrectomy (left kidney).

June, 1909. Dog did very well.

July 11, 1909. Sudden development of anuria followed by death.

Autopsy. Calculus found plugging the ureter. Kidney shows dilated pelvis full of white calculi, one of which had wandered into and blocked the ureter, producing the fatal anuria.

Remarks. In this dog the kidney had been excluded three weeks before it was allowed to resume its work, and after this period it was still capable of doing the necessary excretory work. No signs of renal insufficiency developed until the accidental blocking of the ureter by a calculus took place.

Experiment. (38). Fox terrier.

August 16, 1909. First operation. Ligation of right ureter close to bladder.

September 15, 1909. Anastomosis of ureter and bladder thirty days after the first operation. Cultures showed Staphylococcus albus.

December 13, 1909. In good condition.

February 19, 1910. Nephrectomy (left kidney).

February 20, 1910. Doing well.

Urinalysis. Specific gravity, 1030; alkaline reaction; faint trace of albumin; 2 per cent. urea; phosphates and pus cells.

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[3] I take this opportunity to thank Dr. H. Celler for the bacteriological examinations which he very kindly made for me.

February 21, 1910. Total urine gathered, 345 c.c.; specific gravity, 1020; alkaline; 1.5 per cent. urea.

February 22, 1910. Total urine gathered, 480 c.c.

February 23, 1910. Total urine gathered, 750 c.c.

February 27, 1910. Total urine gathered, 720 c.c.

March 5, 1910: Dog in excellent shape. Continues to take food well; no vomiting; active and growing fat.

March 19, 1910. In excellent condition.

April 8, 1910. Killed. Autopsy showed a large stone in bladder, three-quarters of an inch in diameter. New ostium patent. Right ureter somewhat dilated. Right kidney is approximately one-third the size of the previously excised left kidney, which had been removed February 19, 1910. It measures one inch in the vertical and one-half inch in transverse diameter.

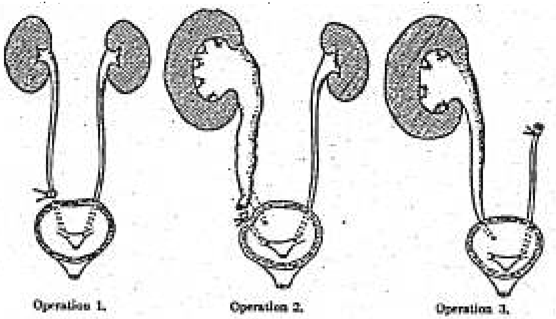

Fig. 8.—Series testing functional adequacy.

Remarks. This dog lived satisfactorily on the right kidney, which did all the necessary excretory work, even though it had been excluded for thirty days. In still another dog (Case 40) I excluded a kidney for thirty-seven days, and when it was tested by the same physiological test, that is, forced by nephrectomy of the second organ to do all the work, it excreted four days after the nephrectomy 650 c.c. of urine, which on testing was alkaline in reaction, contained a faint trace of albumin, urea 1.6 per cent. (10.4 grams). Subsequently this animal developed signs of insufficiency, and vomiting set in, followed by anuria and death.[4]

Resume. From such experimental data it is evident that even after three or four weeks exclusion of a kidney, sufficient parenchyma is preserved to carry on the excretory work of the organism. Whether these results in dogs can be transferred to humans, experience alone can tell us. The knowledge gained from these data are very suggestive and in future if an operator resorts to ligation of a ureter, he must bear in mind the fact that the excluded kidney may be made a useful organ if an anastomosis is made within three to four weeks of the original exclusion.

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[4] Fig. 8 illustrates the various steps taken to test the adequacy of the excluded kidney.

From the work done in connection with this subject, the following conclusions seem justified:

1. Infection of a non-stenosed ureter may lead to a hydronephrosis. Perhaps this explains some of the cases of hydronephrosis in which no mechanical cause is found.
2. Infection of the ureter rarely leads to abscess formation, to multiple abscesses of kidney, unless the ureter is stenosed and then only when the injected organisms are virulent.
3. Aseptic ligation of ureter leads regularly to a primary hydroureter and at about three weeks atrophy and shrinkage of the hydronephrotic sac begins.
4. The idea that the use of catgut ligature material in pelvic work will not cause a permanent ureteral stenosis, if this organ is tied off, is erroneous.
5. Three to four months after ligation of the ureter the kidney is represented by a small fibrous mass, provided infection is not present. If infection is introduced a huge hydronephrotic sac without vestige of parenchyma results.
6. In face of infection, stones readily form both in the pelvis and bladder.
7. After three weeks' exclusion sufficient parenchyma persists to warrant an attempt at secondary implantation of the ureter into the bladder.

THE USE OF THE CREHORE MICROGRAPH IN THE CLINICAL AND EXPERIMENTAL STUDY OF CARDIOVASCULAR PHYSIOLOGY.[1]

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AND
George Morris Piersol, M.D.,
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(From the John Herr Musser Department of Research Medicine, University of Pennsylvania.)

In the last few months we have attempted to use the Crehore micrograph[2] for the study on animals of (1) the time relations of

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[1] Read before the Philadelphia Pathological Society, May 9, 1912.

[2] Amer. Jour. Med. Sci., 1912, cxliii, 193.